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CIRCUIT BOARD MANUFACTURING METHOD

[Haisenban no seizou houhou]

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Claim

A circuit board manufacturing method that is characterized by being constituted by filling depressions in an insulating substrate, in which an inner wiring layer has been formed, with resin and providing at least an adhesive resin layer, and then forming through-holes traversing the insulated wiring and forming metallic layers on the inner wall thereof, and by the resin used to fill the depressions comprising 10 parts by weight to 50 parts by weight epoxy resin with a molecular weight of 5,000 or greater, 5 parts by weight to 25 parts by weight alkylated melamine resin, 5 parts by weight to 50 parts by weight saturated polyester resin, and 10 parts by weight to 40 parts by weight inorganic fibrous filler per 100 parts by weight epoxy resin with a molecular weight of 5,000 or less, and a cross-linking agent.

Detailed explanation of the invention

Industrial application field

This invention pertains to a method of manufacturing circuit boards that use metallic wire with an insulating layer (hereinafter referred to as wire) in wiring patterns.

Prior art

Multiwire circuit boards (hereinafter, referred to as MWB) have been proposed (Japanese Kokoku Patent No. Sho 50[1975]-2063) in which wire is adhered to an insulating substrate that is catalytic with respect to electroless plating, after which, an insulating resin is affixed, a through-hole is formed traversing the aforementioned wire, and a metallic layer formed by electroless plating is disposed inside this hole. This type of circuit board possesses the following characteristics.

1) Since wire is used as the pattern conductor, it is possible for wires to intersect in the same plane, and they can therefore be bonded to the circuit board by the etched foil method, doubling the wiring capacity per layer.

2) It is suited to the production of small quantities of a large variety of products since it can be directly "drawn on" by a wiring pattern wiring machine (a device that simultaneously lays out and adheres wire onto an insulating substrate).

3) It exhibits excellent electrical characteristics since the wire pattern conductor is covered with an insulator.

4) There are no short circuits since it is realized simply by through-holes in the substrate surface.

Therefore, these boards have been widely used in computer-related and industrial equipment, such as numerical controllers and communications equipment, etc.

The demand for circuit boards has recently increased, and amidst this, since circuit board capacity has increased with increased integration in semiconductor elements, controlling the characteristic impedance among the electrical properties has become a crucial problem. In order to increase the circuit board capacity, the number of layers has been increased or the wiring density has been increased and the diameter of the wire used has been decreased from 0.14-0.16 mm in the past to 0.06-0.10 mm, so that 2 to 3 wires can be fit within 100 mil, or 1 to 2 wires can be fit between 50 mil pins.

Meanwhile, the characteristic impedance (Z_0) is correlated with the wire diameter (2r), the distance (h) between the wire and the ground layer, and the dielectric constant (εr) of the material used between the wire and the ground layer (adhesive resin layer), and is expressed in the case of a MWB by the following equation.

$$Z_0 = \frac{60}{\sqrt{\varepsilon_{re}}} \ln \frac{2h}{r}$$

wherein, $\varepsilon_{re} = f(\varepsilon_r)$

Consequently, as the wire diameter is decreased to improve wiring density, the characteristic impedance increases, making it impossible to meet the $Z_0 = 50\ \Omega$ demanded in ECL among ICs. Measures taken to resolve this included a method of increasing the εr of the material between the wire and the ground layer, and a method of decreasing the distance (h) between the wire and the ground layer. In the former method of increasing the εr of the adhesive resin, fulfilling the heat resistance and plating characteristics, etc., is difficult plus the εr is increased. On the other hand, in the latter method, $Z_0 = 50\ \Omega$ (where the wire diameter is 0.10 mm) is met if the thickness of the adhesive resin layer is reduced from the approximately 300 μm of the past to 100-150 μm.

When this adhesive resin layer is applied under heat and pressure to the mirror plate of an insulating substrate, on which a circuit of a 70-105-μm thick conductor has been formed, covering the mirror plate, the surface of the adhesive resin is flat and smooth, but the distance to the conductor circuit surface is shorter. Because of this, the effect of reflected ultrasonic waves applied by a wiring probe to melt the wire cladding differs, causing problems in which the energy reflected by the wiring in the conductor circuit is intensely impressed on the wire, causing breaks in the wire.

Meanwhile, applying silicone rubber, etc. under heat and pressure between the mirror plate and the adhesive resin makes the distance between the conductor circuit substrate surface and the adhesive resin layer surface uniform, but also creates irregularities on the surface. Therefore, since ultrasonic energy from a wiring probe held at a constant height can not efficiently melt the wire cladding, but is used to vibrate wires, problems occur in that wire is lifted off the surface.

Methods have been proposed as a countermeasure in which depressions in the inner wiring layer are filled with a resin comprising an epoxy resin or NBR (acrylonitrile butadiene rubber), as seen in Japanese Kokai Patent Application No. Sho 61[1986]-105890.

Problems to be solved by the invention

However, this method has a major problem in that the insulation degrades under high-temperature electrical conduction.

This invention uses the aforementioned resin filling method to provide a method of manufacturing multiwire circuit boards with high-density wiring using 0.10 mm wire and that meet $Z_0 = 50\ \Omega$ and have excellent insulation deterioration properties.

Means to solve the problems

The details of this invention will be explained based on the attached figures.

Figure 1 shows a case in which a power supply and ground circuit 3 are formed with an inner wiring layer on an insulating substrate 2 of inner wiring later circuit board 1 by a commonly known etching method. Next, constituents comprising 10-50 parts (by weight, hereinafter the same) epoxy resin with a molecular weight of 5,000 or greater, 5-25 parts alkylated melamine resin, 5-50 parts saturated polyester resin, and 10-40 parts inorganic fiber filler per 100 parts epoxy resin with a molecular weight of 5,000 or less, and a cross-linking agent are dissolved and dispersed into a mixed solvent of cellosolve acetate or methyl ethyl ketone, etc., applied to a separation film of polypropylene or silicone-treated polyester film, etc., and then cured to a B-stage state. This is then laid over the aforementioned inner wiring layer circuit board 1, a mirror plate is layered on, and heat and pressure are applied to form the smooth surface resin layer 4 shown in Figure 2. Examples of epoxy resins with a molecular weight of 5,000 or less used in the resin that is used to fill the depressions include Yuka-Shell Epoxy Co. products Epikote 828, 834, 871, 872, 1001, 1002, 1003, 1004, and 1007, Dow Chemical Co. products D.E.R. 317, 330, 331, 361, 661, 662, 664, 667, 732, and 736, and D.E.N. 431, 438, 439, and 485, etc. as well as Dow Chemical Co. brominated epoxy resin products D.E.R. 511 and 542, etc.

Epoxy resins with a molecular weight of 5,000 or greater include Yuka-Shell Epoxy Co. products Epikote OL-53-L-32, OL-53-BH-35 (molecular weight 55,000), OL-55-L-32, 1255-HX-30 (molecular weight 70,000 or greater), Tohto Kasei Co. products Pheno Tohto YP-40 (molecular weight 20,000), YP-50M (molecular weight 30,000), YP-50 (molecular weight 40,000), and Union Carbide Co. products PKHH and PAHJ (molecular weight 40,000), etc. These high-molecular weight epoxy resins are commonly called phenoxy resins. The quantity added of the above is limited to the range of 10 parts to 50 parts because if it is less than 10 parts, the resin flow increases, making for poor board thickness precision. Meanwhile, at greater than 50 parts, the resin flow decreases, causing trapping of air in depressions in the insulating substrate.

Examples of alkylated melamine resins include Hitachi Chemical Co. products Melan 520, 521, 522, and 523 (methylated melamine resins), and Melan 20, 22, 23, 25, 26, x65, and 66 (butylated melamine resins), etc. The quantity of alkylated melamine resin is limited to the range of 5 parts to 25 parts because the heat resistance decreases outside this range. Saturated polyester resin is added for the purpose of providing flexibility, and a molecular weight of 20,000 to 40,000 is preferred. Commercial products that can be used include Toyo Spinning Co. products Vylon 300, 500, and 600, etc. The additive quantity range is limited to 5 parts to 50 parts because at less than 5 parts, the flexibility decreases, causing the resin layer on the carrier film to crack during handling. In addition, the heat resistance decreases at greater than 50 parts. It is preferred that the inorganic fibrous filler be short glass fibers (3-20 μm diameter, 50-200 μm long), and commercial products include Asahi-Scheibel Co. AGP-01/BZ. The purpose of the filler is to improve adhesion to the copper plating layer in the through-holes and to improve thermal shock resistance. Wear on drill bits increases if more than 40 parts is added. Meanwhile, the thermal shock resistance decreases at less than 10 parts.

It is preferable to use a mixture of an imidazole derivative and an acidic organic compound with at least one radical of one or two or more selected from a group comprising radicals that exhibit acidity, such as carboxyl radicals, sulfonic acid radicals, hydroxyl radicals, etc., as the cross-linking agent. This is because, first, the catalytic action of the acidic organic compound precipitates a reaction between the alkylated melamine resin and the epoxy resin during formation of the coating film, which improves its fluidity in the semi-solidified state, and second, the imidazole derivative causes the epoxy radical to cure during heat curing, which improves heat resistance and insulation degradation properties under electrical current.

Examples of imidazole derivatives include Shikoku Chemicals Corp. products 2MZ (2-methyl imidazole), 2E4MZ (2-ethyl-4-methyl imidazole), $C_{i1}Z$ (2-undecyl imidazole), 2PZ (2-phenyl imidazole), 2MZ-CN (1-cyanoethyl-2-methyl imidazole), 2E4MZ-CN (1-cyanoethyl-2-ethyl-4-methyl imidazole), and 2PZ-CN (1-cyanoethyl-2-phenyl imidazole), etc., examples of acidic organic compounds with a carboxyl radical include benzoic acid, nitrobenzoic acid, anisic acid, benzoic acid halides, salicylic acid, phthalic acid, trimellitic acid, and naphthoic acid, etc., examples of those with a sulfonic acid radical include benzene sulfonic acid, toluene sulfonic acid, naphthalene sulfonic acid, and naphthol sulfonic acid, etc., and examples of those with a hydroxyl radical include picric acid, etc. Commercial imidazole derivatives and salts of acidic organic compounds include Shikoku Chemicals Corp. products 2E4MZ-CNS (1-cyanoethyl-2-ethyl-4-methyl imidazole · trimethylate) and 2PZ-CNS (1-cyanoethyl-2-phenyl imidazole · trimethylate), etc.

These imidazole derivatives and acidic organic compounds are appropriately combined according to the intensities of their respective basicity and acidity, and the hardness of the resin layer can be optimized by changing their ratios.

Next, an adhesive resin layer 5 is laminated, as shown in Figure 3, after which wire 6 fed from a numeric control wiring machine, which is able to trace a desired wiring pattern on the surface, is

ultrasonically melted and adhered. The aforementioned adhesive resin layer that is used may be one made from a thermoplastic resin, such as natural rubber, acrylonitrile butadiene copolymer, or butadiene rubber, etc., and a thermosetting resin, such as epoxy resin, phenol resin, or melamine resin, etc., which are dissolved in an organic solvent, such as methyl ethyl ketone, toluene, or cellosolve acetate, etc., and then cured in sheet form. Furthermore, an epoxy-prepreg glass cloth may be disposed between the resin layer 4 and the adhesive resin layer 5, if needed, to control Z_0.

Next, in order to affix the aforementioned wire, as shown in Figure 4, after the prepreg, etc. are heated under pressure to form the thermosetting resin layer 7, a hole is drilled and a through-hole copper plating layer 8 is disposed on the inner wall of the hole, whereby a multiwire circuit board is manufactured. Furthermore, the insulating substrate 2, resin layer 4, adhesive resin layer 5, and thermosetting resin layer 7 may all be catalytic to electroless plating. This can be achieved by adding 0.01-1.00 part by weight palladium chloride, gold chloride, or copper (II) chloride, etc. to 100 parts by weight of the resins that constitute the layers.

The circuit board of this invention, described above, has a smooth surface on which the irregularities of the conductor circuit disposed on an insulating substrate surface are filled in a void-free manner with a resin composition of superior insulating properties, thermal shock resistance, and drillability, etc. Consequently, since this surface can be formed on any adhesive resin layer of 100 μm or greater thickness, there are no problems with broken wires, etc. during wiring, and a characteristic impedance of 50 Ω or greater can be achieved at a wire diameter of 0.10 mm.

Example embodiment

A multiwire circuit board was manufactured by the following process.

1) A power supply and ground circuit was formed by a commonly known etching method, using a catalyst-containing glass cloth epoxy laminate board MCL-E-168 (trade name, Hitachi Chemical Co., Ltd.).

2) The resins shown in Table 1 were applied to Tedlar film (trade name, DuPont Co.) to 50 μm after drying, and then semi-hardened under drying conditions of 130C° for 5 min and 160°C for 5 min.

This was disposed on both sides of the aforementioned inner layer circuit board, and then heat and pressure were applied at 170°C, 45 kg/cm^2 for 30 min.

3) The Tedlar film was removed and a catalyst-containing adhesive resin (trade name HA-05, Hitachi Chemical Co., Ltd.) was applied to both sides to a thickness of 150 μm, and then heat and pressure were applied at 160°C, 20 kg/cm^2 for 15 min.

4) Insulation-clad copper wire, in which 10 μm of polyamide imide resin H1404 (trade name, Hitachi Chemical Co., Ltd.), and then 10 μm of thermoplastic polyester resin WS451 (trade name, Hitachi Chemical Co., Ltd.) were applied to 0.10 mm diameter copper wire, was laid out and affixed into a desired wiring pattern.

5) A glass cloth epoxy prepreg GEA-168N (trade name, Hitachi Chemical Co., Ltd.) was layered on the surface of this substrate and heated under pressure at 175°C, 30.0 kg/cm^2 for 70 min. An adhesive-backed polyethylene film (Hitalex S-500X-9, trade name, Hitachi Chemical Co., Ltd.) was then glued by hot lamination to both sides.

6) Through-holes were formed at specified locations with a 0.5 mm-diameter drill.

7) After immersion for 30 min in a 40°C aqueous solution of 60g/L anhydrous chromic acid and 300 mL/L concentrated sulfuric acid, this was then immersed for 20 min in an R.T. aqueous solution of 20 g/L sodium hydrogen sulfite. Next, it was rinsed in flowing water for 20 min.

8) After immersion for 1 min in a 10% H_2SO_4 aqueous solution, it was rinsed in flowing water for 1 min.

9) Next, it was immersed for 30 min in an electroless copper plating solution (solution temperature 68°C) to form a 35-μm thick copper layer.

Electroless plating solution composition

Copper sulfate	10.0 g/L
Sodium ethylenediamine tetraacetate	35.0 g/ L
37% formalin	5.0 m L/L
Sodium cyanide	40.0 mg/ L
FC128 (trade name, Sumitomo 3M Ltd.)	0.1 g/ L

10) The aforementioned polyethylene film was then peeled off.

The multilayer circuit board obtained in this manner had a high wiring density with a wiring density of 3 wires/100 mil using 0.10 mm-diameter wire, and a characteristic impedance of 50 ± 5 Ω. In addition, there were no broken wires during wiring, and after 300 cycles of the MIL-STD-202E-107Ccord.B thermal shock test, no corner cracks or breakdowns at the wire connections were seen. (Number of tests: 5 circuit boards with 5000 through-holes)

No abnormalities were found in heat resistance when viewed in cross-section after floating for 5 min in a 260°C solder bath.

As an insulation degradation test, boards were treated for 3,000 h under the condition of 100°C power supply 100 VDC/0.25 mm impressed between through-holes, but no abnormalities were observed.

Effect of the invention

The following benefits were achieved in the multiwire circuit board manufacturing method of this invention, as described above.

1) A multiwire circuit board can be manufactured that simultaneously meets a high wiring density with a wiring density of 3 wires/100 mil using 0.10 mm-diameter wire, and a characteristic impedance of 50 Ω or greater.

2) The insulation degradation characteristics between the inner wiring layer and through-holes are improved since a resin composition layer with good insulation characteristics is provided in the power supply, ground circuit.

Brief description of the figures

Figure 1 through Figure 4 are sectional drawings that show the manufacturing process of this invention.

Explanation of symbols

1	inner wiring layer circuit board	2	insulating substrate
3	power supply, ground circuit	4	resin layer
5	adhesive resin layer	6	wire
7	thermosetting resin layer	8	through-hole copper

TABLE 1

	Trade name	Manufacturer	Application Example 1	Application Example 2	Application Example 3
Epoxy resin (Molecular weight <5,000)	Epikote 1001	Yuka-Shell	90	90	90
	Epikote 154		10	10	10
Epoxy resin (Molecular weight ≥5,000)	YP-50	Tohto Chemical	20	20	
	PKHH	Union Carbide			40
Alkylated melamine	Melan 20	Hitachi Chemical			20
	Melan 523		8	8	
Saturated polyester	Vylon 300	Toyo Spinning	25		45
	Vylon 500			30	
Cross-linking agent	2PZM-CN	Shikoku Chemicals	1	1	2
Filler	AGP-01/BZ	Asahi Scheibel	25	25	40
Plating catalyst	Cat 10	Hitachi Chemical	4.6	4.6	6.1

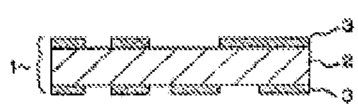

Figure 1

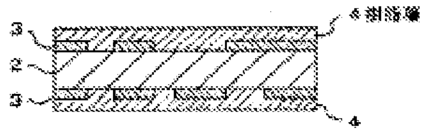

Figure 2

Key: 4 Resin layer

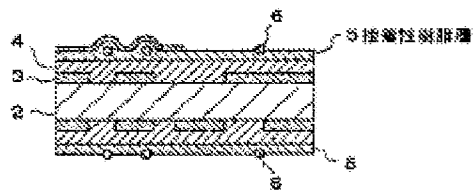

Figure 3

Key: 5 Adhesive resin layer

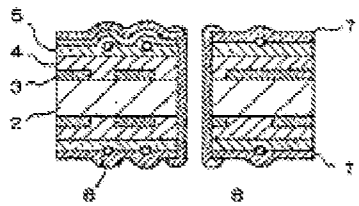

Figure 4